FINAL REPORT

IMPROVED TREES AND TECHNOLOGY FOR CHRISTMAS TREE PRODUCTION IN SASKATCHEWAN

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February 2001

Prepared by: Saskatchewan Christmas Tree Growers Association

AGRI-FOOD INNOVATION FUND

Canada

Saskatchewan

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Final Report

AFIF Project 96000377

Saskatchewan Christmas Tree Growers Association

February, 2001

AGRI-FOOD INNOVATION FUND

Canada Saskatchewan

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A. Summary

The project has resulted in the establishment of seed orchards at Meeting Lake PFRA Pasture and the Melfort Research Station. The orchards are made up of selected plus trees of Scots pine and balsam fir. The balsam fir was selected from stands in the boreal forest, scions collected form these trees were grafted on fir rootstock. The Scots pine were seedlings with dark green foliage selected from nursery fields. These orchards will provide growers with a long term supply improved Scots pine and balsam fir seed. The project investigated the utilization of fertilizer to increase growth rates and improve quality of Scots pine and balsam fir trees. Results indicated that there little benefit was realized from fertilizing trees in plantations that were established on agricultural soils. A growers guide to fertilizing Christmas trees was also produced.

The results from the project are providing growers with technical information on fertilization that will enhance their production capabilities. Although it will take longer to realize the benefits, the establishment of the seed orchards will have significant long term impacts on the industry. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. These seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality.

B. Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality.

Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more. The project is being conducted in co-operation with the PFRA Shelterbelt Centre at Indian Head. Project funding was from the Canada-Saskatchewan Agri-Food Innovation Fund. The objectives of the project are to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities

2.1 Tree Improvement

2.1.1 Balsam Fir (*Abies balsamea*)

The tree improvement phase of the project was initiated in February, 1998 with the selection of superior balsam fir phenotypes from native stands at Candle Lake, Weyakwin, Meadow Lake, Big River and Island Lake, Saskatchewan. A total of 20 trees were selected during the study. Selection criteria included blue-green needle colour, crown form and density. Scions were collected by felling the trees and collecting branches. The selected trees were propagated by grafting scions on balsam fir seedling rootstock. Additional collections of balsam fir were conducted in February 1999 and 2000. A grafting technique was developed and is described in Appendix 1 of the final report. Grafting success was 60 percent with a total of 425 trees grafted.

2.1.2 Scots Pine (*Pinus sylvestris*)

Scots pine trees in shelterbelts and nursery transplant fields were evaluated and the best trees and seedlings selected according to colour, needle sharpness and bole straightness (trees only). Trees or seedlings with dark green foliage colour in early winter were identified in the selection process. A total of 500 seedlings were selected from the nursery transplant plots and 20 trees were selected . Foliage samples were obtained from each selected as well as randomly selected control plants. Using a Munsell colour chart for plant tissue needle colour (Hue, Value & Chroma) of each foliage sample was determined. Needles were also categorized as being either sharp or blunt. Needle length of samples was also determined.

When the selected seedlings were compared to the control seedlings 76 percent had colour ratings of 5GY or 7.5GY on the Munsell colour chart whereas, the control seedlings had a colour rating of 2.5GY. Needle sharpnesss was determined for each seedling. Of the 500 selected plants, 54 percent were classified as having blunt needles. This compared to 50 percent for the randomly sampled control plants. The selected trees were potted and maintained in a holding nursery at the PFRA Shelterbelt Centre until planting in the seed orchards.

2.2.3 Seed Orchards

Meeting Lake Seed Orchard

The Meeting Lake seed orchard is located immediately west of the pasture managers residence at the Meeting Lake PFRA Pasture. The orchard was planted in May, 1999. A total of 148 trees were planted in the orchard. Eighty-one Scots pine trees were planted representing seedlings selected from transplant plots at the Shelterbelt Centre and 67 grafted balsam fir trees representing seven sites from their native range in northern Saskatchewan. Two separate tree blocks were established, one block consisted entirely of Scots pine, whereas the second block was Scots pine and balsam fir. Planting holes were prepared for the pots using a post hole auger. Plastic mulch was laid over the holes in rows. Trees were hand planted through the mulch and hard fescue grass was sown between mulched tree rows. Trees were spaced 4.5 meters apart in the row. Between row spacing was 6.0 meters. A 2.5 meter high deer fence was placed around the orchard. Planting plans and site diagrams for the Meeting Lake seed orchard

are shown in Appendix 1. In June 2000, 11 balsam fir were planted to replace dead trees.

Melfort Seed Orchard

The Melfort seed orchard is located at the Melfort Research Station. The orchard was planted in late August, 2000 A total of 457 trees were planted in the orchard. This includes 111 Scots pine trees and 346 balsam fir. Planting holes were prepared for the pots using a post hole auger. Trees were hand planted and then watered. Plastic mulch (1 meter squares) was placed around each seedling. Trees were spaced 4.5 meters apart in the row. Between row spacing was 6.0 meters. The area between mulched trees was grassed. No deer fencing was required at the this site Planting plans and site diagrams for seed orchard are shown in Appendix 1.

2.2 Fertility Requirements

Fertility levels for Scots pine and balsam fir growing in existing orchards were evaluated. Maximizing growth and high quality trees are important factors in economic sustainability of Christmas tree production. Tree quality is dependent on having vigorous, healthy trees with green needle colour. Conifers normally respond to applications of nitrogen fertilizer, but show limited or no improved growth following application of phosphorous or potassium. In this phase of the project we concentrated on determining the effects of nitrogen applied in 1998 to Scots pine and balsam fir Christmas tree plantations.

2.2.1 Methods

Test sites were located at Christmas tree orchards near Prince Albert, North Battleford, Kenaston and Indian Head, Saskatchewan. In the spring of 1998 five levels of nitrogen fertilizer applied in the spring (four fertilizer treatments plus a non-fertilized check) to balsam fir at Prince Albert and North Battleford and Scots pine trees at all the test sites. For each species the study was arranged in a Randomized Complete Block design with four, five tree replications per treatment. A total of 100 trees per species per site were used in the study. The plot means of all parameters were compared using ANOVA and Regression analysis.

1. 58g Nitrogen/Tree
2. 116g Nitrogen/Tree
3. 232g Nitrogen/Tree
4. 348g Nitrogen/Tree
5. Non-fertilized Check

A composite twig sample consisting of the distal 2 to 4 cm portion of the most northerly lateral shoot of each tree was collected in October 1998. For both species the number of lateral buds, number of terminal buds, weight of terminal buds, needle length, needle weight and needle colour were determined. Needle colour was determined using Munsell colour charts for plant tissue. Needles from each twig sample were compared to the colour chart and hue, chroma and value determined. The percentage of needles with a Hue of 7.5GY was determined for each treatment. For Balsam fir, needle nitrogen was determined by EnviroTest laboratories in November 1998. The tests at Prince Albert could not be analyzed because high rates of nitrogen had significantly damaged the trees which were smaller and

younger at the time of fertilizer application than trees at the other test sites. Soil samples were collected (0-30 cm depth) from two plots per treatment per site and available nitrogen determined at the PFRA Shelterbelt Centre in November 1998.

2.2.2 Results

Soil analysis indicated that available nitrogen levels varied according to the amount of nitrogen applied the previous growing season. When needle characteristics were compared at each site it was found that available nitrogen had no significant effect. Analysis of Variance (ANOVA) indicated that there were no significant differences among treatments for any of the variables measures. Similarly, Regression analysis showed no significant relationships between soil nitrogen levels and needle characteristics. Tissue nitrogen percentage in balsam fir ranged from 1.9 to 2.0. These levels are within normal ranges and indicate that nitrogen was not limiting. Based on the results from two years study it appears that nitrogen fertilization of Scots pine or balsam fir in Christmas tree plantations is not necessary as growth or needle quality is not enhanced.

Table 1: Needle data for Scots pine at North Battleford.

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	9.2	20	5	0.21	9.1	5.3	70
2	14	19	7	0.29	9.6	4.4	50
3	29	23	6	0.23	10	4.5	85
4	39.9	19	6	0.26	8.8	3.4	60
Check	7.4	23	6	0.26	10.6	6	89

Table 2: Needle data for Scots pine at Kenaston

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	13.2	21	9	0.27	8.5	4.1	45
2	26.3	23	9	0.23	8.6	4.2	50
3	28.8	24	6	0.16	7.9	4	55
4	56.3	21	8	0.17	8.5	4.3	65
Check	8.3	21	9	0.21	8.6	3.5	55

Table 3: Needle data for Scots pine at Indian Head

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	13.5	25	9	0.38	9.7	4	75
2	36.1	26	8	0.3	9.5	4	85
3	44.8	27	10	0.35	10	4.9	80
4	156.2	25	9	0.31	9.7	5.1	80
Check	14.4	24	7	0.23	9.1	4.3	85

Table 4: Needle data for Balsam Fir at North Battleford

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Tissue Nitrogen (%)	Needle Colour (%)
1	2.5	21	7	0.09	2.3	0.59	1.9	60
2	17.3	18	7	0.13	2.5	0.67	2	60
3	27.4	15	7	0.11	2.4	0.64	2.2	50
4	70.2	19	7	0.11	2.4	0.73	2.1	45
Check	3.2	21	6	0.09	2.4	0.53	1.9	50

Comparison of needle characteristics for Scots pine trees at North Battleford, Kenaston and Indian Head indicated that trees at Indian had greater numbers of lateral and terminal buds and a higher percentage of trees with dark green needle colour (Table 5). The trees at the Indian Head site originated were a selected strain of Scots pine developed at the PFRA Shelterbelt Centre specifically for Christmas tree production, whereas the trees at the other sites are of different origins.

Table 5: Comparison of soil and needle data for Scots pine at North Battleford, Kenaston and Indian Head.

Site	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
North Battleford	19.9	21	6	0.25	9.6	4.7	71
Kenaston	26.6	22	8	0.21	8.4	4	54
Indian Head	53	25	9	0.31	9.6	4.5	81

2.2.3 Fertility Recommendations and Conclusions

1. Foliage characteristics including needle colour were not significantly or consistently better for trees that had been fertilized.

2. Nitrogen fertilization did not significantly increase lengths of terminals or other shoots of trees growing at any of the sites.

3. There was variation in growth and foliage characteristics of individual trees and between sites. Part of the variation was probably related to differences in soil drainage and compaction between and within plantations. Variations were also probably related to genetic differences between trees and nitrogen fertilization will not overcome all of that variation. Genetic selection of progeny from specific locations, individual mother trees and/or individual trees is required to enhance overall appearance of foliage. This work is under way in this project.

4. Excessive (>100kg/ha) applications of nitrogen can result in mortality of young seedlings. Heavy application of nitrogen had no adverse effects on trees one metre or larger.

5. Fertilization does not appear to be worthwhile on Christmas plantations established on agricultural soils.

2. Indications for Further Development

The orchard establishment and fertility phases of the project have been completed. Further work including orchard maintenance and seed collection will be conducted by the Saskatchewan Christmas Tree Growers Association and PFRA.

3. Information Sharing

2000 - A review and summary of the project was prepared and presented at the Saskatchewan Christmas Tree Growers Association Annual meeting in Prince Albert, March 25, 2000 and the AFIF conference in Regina, November 7, 2000. Signs recognizing project partners including AFIF, Saskatchewan Christmas Tree Growers and PFRA are erected at both orchard sites.

1999 - A review and summary of the project was prepared and presented at the PFRA Shelterbelt Centre Field Day in July, 1999. A review and summary of the project was prepared and presented at the AFIF Horticultural conference in Saskatoon.

1998 - A review and summary of the project was presented to the annual meeting of the Saskatchewan Christmas Tree Growers Association in Prince Albert in March. A review of the project was presented to the annual Saskatchewan Christmas Tree Growers Association Field day held at Prince Albert in August. A news release was prepared by Saskatchewan Agriculture and Food. The project was described in a news article published in the Western Producer.

1997 - A review of the project was presented to the annual Saskatchewan Christmas Tree Growers Association Field day held at Indian Head in August.

4. Project Success and Relationship with the Objectives

The establishment of seed orchards was at Meeting Lake and Melfort, Saskatchewan was completed. These seed orchard will provide improved seed for Saskatchewan Christmas tree growers.

5. Information on Deliverables

Two balsam fir and Scots pine seed orchards were established one each at Meeting Lake, Saskatchewan and Melfort, Saskatchewan. A fertility fact sheet and was prepared and distributed to Christmas tree growers (see Appendix 3)

C. Personnel

The Saskatchewan Christmas Tree Growers Associsation contracted the PFRA Shelterbelt Centre to provide technical personnel to complete the project. Patrick Moore was employed part-time (5 mos.) for one year of the project (1997-98) and Mark Berry was employed part-time for the final two years (10 mos.) of the project (1999 - 2000).

D. Equipment

No equipment was purchased or rented during the project. Any equipment required was supplied as in-kind support form the PFRA Shelterbelt Centre of Saskatchewan Christmas Tree Growers Association.

E. Project Photos

Project photos are attached.

F. Innovation Fund Acknowledgement

The Agri-Food Innovation Fund was acknowledged during field days, presentations and media interviews regarding the project.

G. Project Public Information Materials

A Christmas tree orchard fertility fact sheet was prepared and distributed to growers. A fac sheet on grafting balsam fir was prepared and distributed. Samples of information materials are shown in Appendix 3.

Appendix 1

Seed Orchard Design
Meeting Lake PFRA Pasture & Melfort Research Station

SCOTS PINE CLONAL SEED ORCHARD
MEETING LAKE PFRA PASTURE - SOUTH BLOCK

Rows EAST to WEST and SOUTH to NORTH

TP = Open- Pollinated Scots pine seedlings selected from transplant plot sat Shelterbelt Centre

TREE #	ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7
1	TP	TP	TP	TP	TP	TP	TP
2	TP	TP	TP	TP	TP	TP	TP
3	TP	TP	TP	TP	TP	TP	TP
4	TP	TP	TP	TP	TP	TP	TP
5	TP	TP	TP	TP	TP	TP	TP
6	TP	TP	TP	TP	TP	TP	TP
7	TP	TP	TP	TP	TP	TP	TP
8	TP	TP	TP	TP	TP	TP	TP
9	TP	TP	TP	TP	TP	TP	TP
10	TP	TP	TP	TP	TP	TP	TP
11	TP	TP	TP	TP	TP	TP	TP
12	TP	TP	TP	TP	TP	TP	TP
13	-	-	TP	TP	TP	TP	TP

SCOTS PINE / BALSAM FIR CLONAL SEED ORCHARD
MEETING LAKE PFRA PASTURE - NORTH BLOCK
Rows SOUTH to NORTH and recorded EAST to WEST

Scots Pine (TP = Open-Pollinated seedlings selected from transplant plots at Shelterbelt Centre)
Balsam Fir (BR = Big River, V = Vodnosky, IL = Island Lake, SB = Site B, W = Weyakwin
ML = Meadow Lake, CL = Candle Lake, T = Tower)

TREE #	ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7	ROW 8	ROW 9	ROW 10
1	TP	TP	TP	TP	TP	BR	BR	ML-1	T	BR
2	TP	TP	TP	TP	TP	IL-6	V-1	ML-6	V	BR
3	TP	TP	TP	TP	TP	V	ML	ML	BR	T
4	TP	TP	TP	TP	TP	V	IL-3	V	V	BR
5	TP	TP	TP	TP	TP	BR	IL-3	T	ML	BR
6	TP	TP	TP	TP	TP	SB	V-5	V	ML	CL
7	TP	TP	TP	TP	TP	TP	BR	ML	BR	BR
8	TP	TP	TP	TP	TP	TP	ML	ML-3	CL	CL
9	TP	TP	TP	TP	TP	TP	BR	IL-1	BR	SB
10	TP	TP	TP	TP	TP	TP	V	BR	ML	ML
11	-	TP	TP	TP	TP	TP	ML-1	IL-6	ML	SB
12	-	TP	TP	TP	TP	TP	BR	BR	T	ML
13	-	TP	TP	TP	TP	TP	ML	V-5	BR	V
14	-	TP	TP	TP	TP	TP	V	IL-5	T	SB
15	-	TP	TP	TP	TP	TP	CL	CL	BR	-
16	-	-	-	-	-	TP	IL-5	IL-1	BR	-

BALSAM FIR/SCOTS PINE MELFORT RESEARCH STATION (2000)

Balsam Fir (ML-Meadow Lake, IL-Island Lake, M-MacDonnell Road, V-Vodnosky Road)

Scots pine= SP-

Rows WEST to EAST and NORTH to SOUTH

ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7
IL-2	ML-6	V-4	SP-2	SP-17	SP-20	SP-TP
IL-3	ML-1	IL-7	SP-27-25	SP-4	SP-4	SP-TP
V-5	M-4	V-5	SP-6	SP-1	SP-7	SP-TP
M-4	ML-4	IL-7	SP-20	SP-2	SP-6	SP-TP
IL-7	V-3	V-4	SP-6	SP-4	SP-12	SP-TP
IL-8	M-5	IL-3	SP-2	SP-1	SP-20	SP-TP
IL-8	IL-3	IL-6	SP-3	SP-16	SP-11	SP-TP
ML-1	IL-3	V-4	SP-13	SP-13	SP-16	SP-TP
ML-1	ML-2	IL-8	SP-20	SP-17	SP-20	SP-TP
V-2	M-4	IL-6	SP-6	SP-16	SP-16	SP-TP
ML-6	IL-6	V-5	SP-2	SP-6	SP-27-25	SP-TP
IL-6	ML-3	ML-2	SP-20	SP-2-25	SP-18	SP-TP
ML-5	IL-2	M-4	SP-1	SP-3	SP-5	SP-TP
ML-6	IL-4	IL-4	SP-6	SP-17	SP-13	SP-TP
IL-7	V-3	ML-6	SP-2	SP-16	SP-14	SP-TP
ML-1	ML-2	V-3	SP-TP	SP-27-25	SP-16	SP-TP
V-2	ML-1	V-5	SP-TP	SP-16	SP-8	SP-TP
ML-1	M-3	IL-7	SP-TP	SP-14	SP-7	SP-TP
IL-7	ML-2	M-5	IL-6	SP-20	SP-16	SP-TP
ML-1	IL-3	ML-1	IL-3	SP-11	SP-4	SP-TP
IL-4	IL-8	V-2	V-4	SP-10	SP-6	SP-TP
V-2	V-3	ML-3	IL-7	SP-11	SP-20	SP-TP
IL-4	IL-4	V-5	V-4	SP-19	SP-11	SP-TP
IL-1	M-5	M-4	M-4	SP-3	SP-17	SP-TP
ML-4	V-3	V-4	IL-7	SP-10	SP-6	SP-TP
ML-4	IL-8	V-3	ML-2	SP-27-25	SP-20	SP-TP
IL-8	IL-6	IL-2	M-4	SP-14	SP-11	SP-TP
V-3	IL-2	ML-2	V-3	SP-9	SP-7	SP-TP
IL-6	V-3	M-3	V-5	SP-17	SP-20	SP-TP
ML-6	V-4	IL-7	M-3	SP-14	SP-16	SP-TP
V-2	ML-4	V-3	V-2	SP-TP	SP-TP	SP-TP

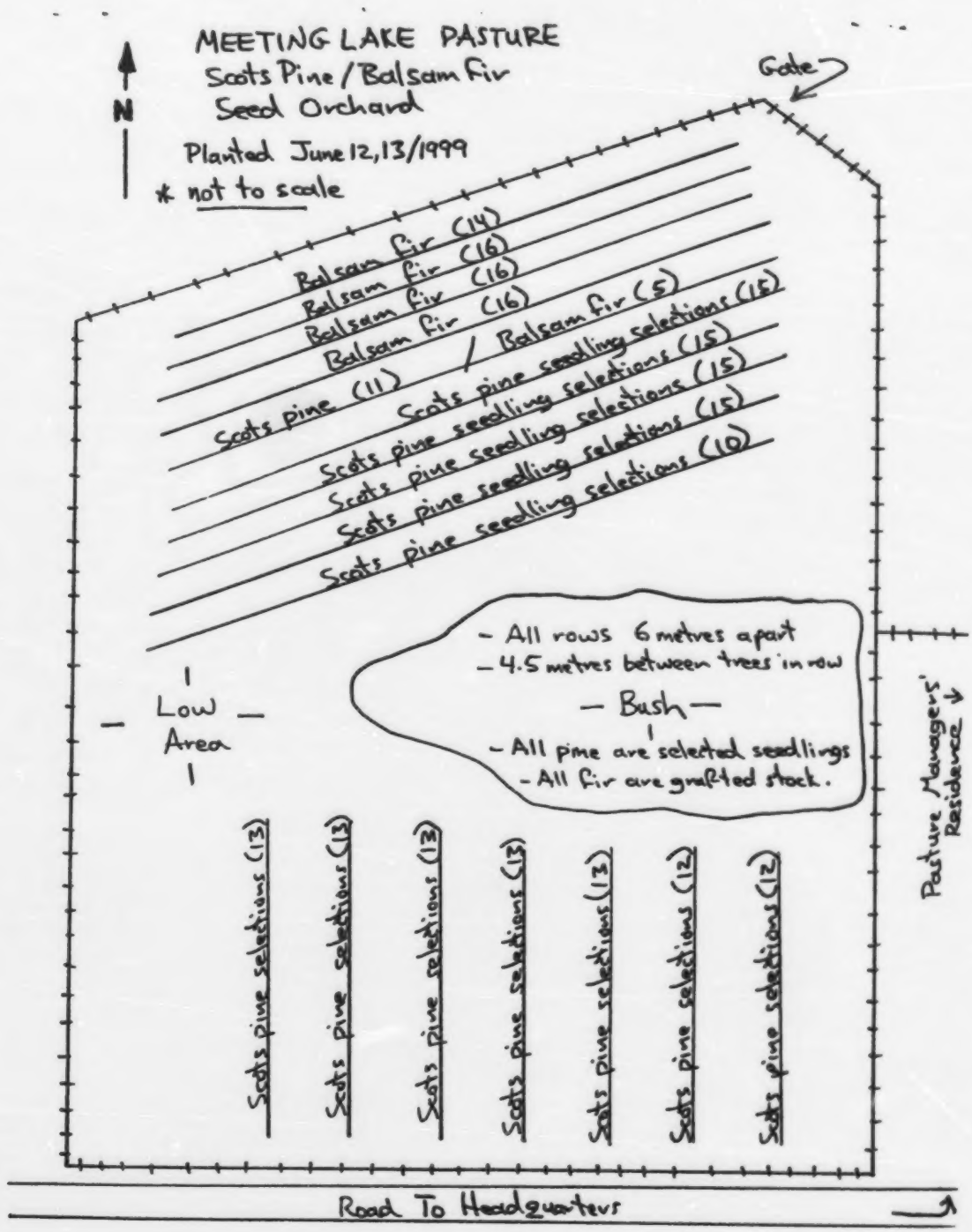
BALSAM FIR/SCOTS PINE SEED ORCHARD -MELFORT LONG ROWS

Balsam Fir (ML-Meadow Lake, IL-Island Lake, M-MacDonnell Road, V-Vodnosky Road)

Scots pine= SP-

Rows WEST to EAST and NORTH to SOUTH

ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7
IL-2	ML-6	V-4	SP-2	SP-17	SP-20	SP-TP
IL-3	ML-1	IL-7	SP-27-25	SP-4	SP-4	SP-TP
V-5	M-4	V-5	SP-6	SP-1	SP-7	SP-TP
M-4	ML-4	IL-7	SP-20	SP-2	SP-6	SP-TP
IL-7	V-3	V-4	SP-6	SP-4	SP-12	SP-TP
IL-8	M-5	IL-3	SP-2	SP-1	SP-20	SP-TP
IL-8	IL-3	IL-6	SP-3	SP-16	SP-11	SP-TP
ML-1	IL-3	V-4	SP-13	SP-13	SP-16	SP-TP
ML-1	ML-2	IL-8	SP-20	SP-17	SP-20	SP-TP
V-2	M-4	IL-6	SP-6	SP-16	SP-16	SP-TP
ML-6	IL-6	V-5	SP-2	SP-6	SP-27-25	SP-TP
IL-6	ML-3	ML-2	SP-20	SP-2-25	SP-18	SP-TP
ML-5	IL-2	M-4	SP-1	SP-3	SP-5	SP-TP
ML-6	IL-4	IL-4	SP-6	SP-17	SP-13	SP-TP
IL-7	V-3	ML-6	SP-2	SP-16	SP-14	SP-TP
ML-1	ML-2	V-3	SP-TP	SP-27-25	SP-16	SP-TP
V-2	ML-1	V-5	SP-TP	SP-16	SP-8	SP-TP
ML-1	M-3	IL-7	SP-TP	SP-14	SP-7	SP-TP
IL-7	ML-2	M-5	IL-6	SP-20	SP-16	SP-TP
ML-1	IL-3	ML-1	IL-3	SP-11	SP-4	SP-TP
IL-4	IL-8	V-2	V-4	SP-10	SP-6	SP-TP
V-2	V-3	ML-3	IL-7	SP-11	SP-20	SP-TP
IL-4	IL-4	V-5	V-4	SP-19	SP-11	SP-TP
IL-1	M-5	M-4	M-4	SP-3	SP-17	SP-TP
ML-4	V-3	V-4	IL-7	SP-10	SP-6	SP-TP
ML-4	IL-8	V-3	ML-2	SP-27-25	SP-20	SP-TP
IL-8	IL-6	IL-2	M-4	SP-14	SP-11	SP-TP
V-3	IL-2	ML-2	V-3	SP-9	SP-7	SP-TP
IL-6	V-3	M-3	V-5	SP-17	SP-20	SP-TP
ML-6	V-4	IL-7	M-3	SP-14	SP-16	SP-TP
V-2	ML-4	V-3	V-2	SP-TP	SP-TP	SP-TP

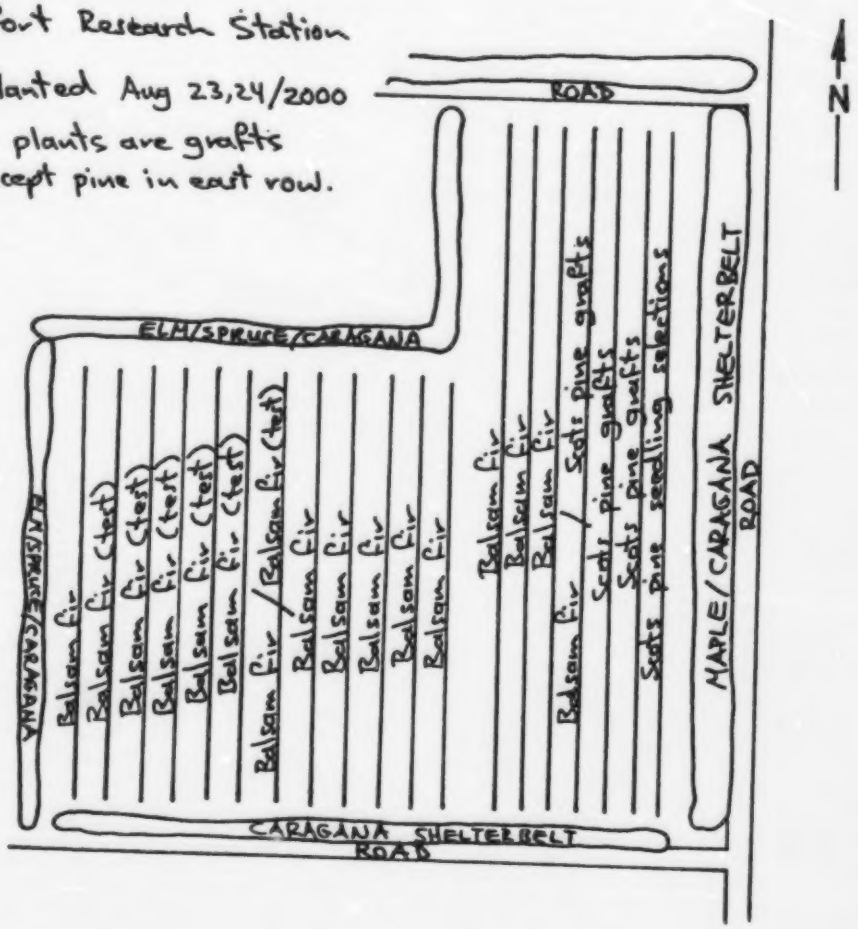

MEETING LAKE PASTURE
Scots Pine / Balsam Fir
Seed Orchard
Planted June 12, 13/1999
* not to scale
N
Gate
Balsam fir (14)
Balsam fir (16)
Balsam fir (16)
Balsam fir (16)
Scots pine (11) / Balsam fir (5)
Scots pine seedling selections (15)
Scots pine seedling selections (15)
Scots pine seedling selections (15)
Scots pine seedling selections (10)
- All rows 6 metres apart
- 4.5 metres between trees in row
- Bush -
- All pine are selected seedlings
- All fir are grafted stock.
Low Area
Scots pine selections (13)
Scots pine selections (13)
Scots pine selections (13)
Scots pine selections (13)
Scots pine selections (13)
Scots pine selections (12)
Scots pine selections (12)
Pasture Managers' Residence
Road To Headquarters

BALSAM FIR/
SCOTS PINE
SEED ORCHARD

Melfort Research Station

Planted Aug 23,24/2000

* All plants are grafts except pine in east row.



Area : - 16296.23 sq metres
- 4.03 acres

Rows : - 6 m apart
- long rows 147.6 metres long (31 trees/row)
- short rows 95.7 metres long (20 trees/row)

Trees : - 4.5 metres apart in row

Appendix 2

Interim and Progress Reports
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

May, 1997 to December, 1999

AFIF Progress Report, July 1 - December 31, 1999
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

Summary

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards. During this reporting period the project concentrated on propagation of superior genotypes of Scots pine and balsam fir and establishment of a seed orchard at Meeting Lake. A second orchard site was selected at the Melfort Research Station and prepared for planting in spring 2000.

Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality. Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more.

The objective of the project is to: 1) provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry; and 2) provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities, July 1 - December 31, 1999

2.1 Tree Improvement

Scots pine trees in shelterbelts selected in 1999 for superior colour were maintained. Additional trees were selected and propagated in) October 1999. The selected trees were potted for planting in spring 2000. Balsam fir trees selected at five sites in northern Saskatchewan that were propagated (grafted) last winter were maintained in a shadehouse located at the Shelterbelt Centre. These trees will be planted at the Melfort seed orchard in 2000. Additional balsam fir will be propagated in February, 2000 for planting in the spring.

The two acre seed orchard at Meeting Lake PFRA pasture was maintained. Survival data was collected in October. Survival of both species was 100 percent. In October, the orchard was enclosed with a deer fence. A second seed orchard site was selected. The site is located at the Melfort Research station. The site was surveyed and prepared for planting in spring 2000.

The remaining Scots pine and balsam fir trees are potted and being maintained in a shadehouse at the PFRA Shelterbelt Centre until planting can be completed in spring 2000.

2.2 Fertility Requirements

There were no activities related to the fertility requirements in this reporting period. Data collection will be completed in October and submitted with the next report.

3. Indications for Further Development

The tree improvement phase will continue in 2000 with the propagation of additional balsam fir and Scots pine and planting of a second seed orchard at the Melfort Research Station.

4. Information Sharing

A review and summary of the project was prepared and presented at the PFRA Shelterbelt Centre Field Day in July, 1999

5. Project Success and Relationship with the Objectives

The seed orchard was at Meeting Lake, Saskatchewan was maintained and fenced to control deer damage. Survival of the trees was 100 percent. This seed orchard will provide improved seed for Saskatchewan Christmas tree growers.

6. Project Expenditures: July 1 - December 31, 1999

	Expenditures July 1 - Dec 31/99	**Total Expenditures to December 31, 1999**
Salary	$4,000.00	$20,000.00
Materials & Supplies	$3,701.35	$ 4,916.68
Travel	$1,331.53	$ 2,113.14
Soil, Plant Analysis	---	$ 1,920.22
Total	$9,032.88	$28,950.04

AFIF Progress Report, January 1 - June 30, 1999
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

Summary

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards. During this reporting period the project concentrated on selection of superior balsam fir and Scots pine phenotypes, propagation of selected trees and establishment of a seed orchard at Meeting Lake. A second orchard site was selected at the Melfort Research Station.

Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality. Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more.

The objective of the project is to: 1) provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry; and 2) provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities, January 1 - June 30, 1999

2.1 Tree Improvement

Scots pine trees in nursery transplant fields were selected according to colour and needle sharpness. Trees or seedlings with dark green foliage colour (as determined by with Munsell colour charts) in early winter were emphasized in the selection process. Other criteria recorded for selected plants was needle length and needle sharpness (Appendix Table 1). The selected trees were potted until planting.

Balsam fir trees were selected at five sites in northern Saskatchewan. The trees were propagated (grafted) in March. Selection of parent trees was based on needle colour and length. Trees were selected from native stands in the Big River, Weyakwin, Meadow Lake, Candle Lake and Prince Albert regions. Trees with blue green needle colour and needles greater than 2 cm in length were selected. Data for selected trees is shown in Appendix Table 2. Needle colour was determined using a Munsell colour chart. Scions (10 per tree) were collected from the twenty selected trees for grafting. Trees were grafted on balsam fir root stock using the side (veneer) grafting technique

A two acre seed orchard including 175 Scots pine and 67 balsam fir was planted at Meeting Lake PFRA pasture in early June 1999. Tree rows were covered with plastic mulch for weed control and moisture conservation, The area between tree rows was seeded with hard fescue. Between row spacing is 6 meters and in row spacing is 2.83 meters. The land location of the orchard is SW Sec 6 Twp 47 Rge 9 W3.

The remaining Scots pine and balsam fir trees are potted and being maintained in a shadehouse at the PFRA Shelterbelt Centre until planting can be completed in October. A second seed orchard site was selected. The site is located at the Melfort Research station. The site is being prepared for planting in October 1999

2.2 Fertility Requirements

There were no activities related to the fertility requirements in this reporting period. Data collection will be completed in October and submitted with the next report.

Indications for Further Development

The tree improvement phase will continue in the fall of 1999 with establishment of a second seed orchard at the Melfort Research Station.

Information Sharing

A review and summary of the project was presented to the annual meeting of the Saskatchewan Christmas Tree Growers Association in Prince Albert in March, 1998.

Project Success and Relationship with the Objectives

A seed orchard was established a Meeting Lake, Saskatchewan. This seed orchard will provide improved seed for Saskatchewan Christmas tree growers.

Project Expenditures: January 1 - June 30, 1999

Information to be provided at a later date as indicated in covering letter.

AFIF Progress Report, July 1 - December 31, 1998
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

Summary

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards. During this reporting period the project concentrated on the continued study of nutrition requirements for Scots pine and balsam fir and selection of superior balsam fir and Scots pine phenotypes. Results after two years indicated that application of nitrogen has no effect on growth and quality of balsam fir and Scots pine growing in Christmas tree plantations. Selection of superior trees and seedlings for seed orchards was completed. Potential seed orchard sites were selected for planting in spring 1999.

Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality. Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more.

The objective of the project is to: 1) provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry; and 2) provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities, July 1 - December 31, 1998

2.1 Tree Improvement

The tree improvement phase of the project was conducted from October to December with the selection of superior Scots pine plants. Scots pine trees in shelterbelts and nursery transplant fields were evaluated and the best trees and seedlings selected according to colour, needle sharpness and bole straightness (trees only). Trees or seedlings with dark green foliage colour in early winter were emphasized in the selection process. A total of 122 seedlings were selected from the nursery transplant plots and 20 trees were selected . Foliage samples were obtained from each selected tree and seedling as well as randomly selected control plants. Using a Munsell colour chart for plant tissue needle colour (Hue, Value & Chroma) of each foliage sample was determined. Needles were also categorized as being either sharp or blunt. Needle length of samples was also determined. For the tree selections bole straightness was also recorded.

Data collected for the seedlings and trees is shown in Appendix Tables 4 & 5. Of the selected

seedlings, 76 percent had colour ratings of 5GY or 7.5GY on the Munsell colour chart. The remaining seedlings had a colour rating of 2.5GY. The ,majority of the randomly selected control seedlings had a colour rating of 2.5GY. Needle sharpnesss was determined for each seedling. Of the 120 selected plants, 65 seedlings or 54 percent were classified as having blunt needles. This compared to 50 percent for the randomly sampled control plants.

Scions (10 per tree) will be collected from the twenty selected trees and grafted for planting in the seed orchards the spring of 1999. The selected seedlings will also be planted in a seedling seed orchard. Seed orchard sites have been tentatively selected at the Meeting Lake PFRA pasture and at Weyerhauser near Henribourg, SK. The sites have been prepared for planting in the spring of 1999.

2.2 Fertility Requirements

Fertility levels for Scots pine and balsam fir growing in existing orchards continues to be evaluated. Maximizing growth and high quality trees are important factors in economic sustainability of Christmas tree production. Tree quality is dependent on having vigorous, healthy trees with green needle colour. Conifers normally respond to applications of nitrogen fertilizer, but show limited or no improved growth following application of phosphorous or potassium. In this phase of the project we concentrated on determining the effects of nitrogen applied in 1998 to Scots pine and balsam fir Christmas tree plantations.

Test sites were located at Christmas tree orchards near Prince Albert, North Battleford, Kenaston and Indian Head, Saskatchewan. In the spring of 1998 five levels of nitrogen fertilizer applied in the spring (four fertilizer treatments plus a non-fertilized check) to balsam fir at Prince Albert and North Battleford and Scots pine trees at all the test sites. For each species the study was arranged in a Randomized Complete Block design with four, five tree replications per treatment. A total of 100 trees per species per site were used in the study. The plot means of all parameters were compared using ANOVA and Regression analysis.

1. 58g Nitrogen/Tree
2. 116g Nitrogen/Tree
3. 232g Nitrogen/Tree
4. 348g Nitrogen/Tree
5. Non-fertilized Check

A composite twig sample consisting of the distal 2 to 4 cm portion of the most northerly lateral shoot of each tree was collected in October 1998. For both species the number of lateral buds, number of terminal buds, weight of terminal buds, needle length, needle weight and needle colour were determined. Needle colour was determined using Munsell colour charts for plant tissue. Needles from each twig sample were compared to the colour chart and hue, chroma and value determined. The percentage of needles with a Hue of 7.5GY was determined for each treatment. For Balsam fir, needle nitrogen was determined by EnviroTest laboratories in November 1998. The tests at Prince Albert could not be analyzed because high rates of nitrogen had significantly damaged the trees which were smaller and younger at the time of fertilizer application than trees at the other test sites. Soil samples were collected (0-30 cm depth) from two plots per treatment per site and available nitrogen determined at the PFRA Shelterbelt Centre in November 1998.

Results

Soil analysis indicated that available nitrogen levels varied according to the amount of nitrogen applied the previous growing season. When needle characteristics were compared at each site it was found that available nitrogen had no significant effect. (Tables 1-4). Analysis of Variance (ANOVA) indicated that there were no significant differences among treatments for any of the

variables measures (Appendix 3). Similarly, Regression analysis showed no significant relationships between soil nitrogen levels and needle characteristics. Tissue nitrogen percentage in balsam fir ranged from 1.9 to 2.0. These levels are within normal ranges and indicate that nitrogen was not limiting. Based on the results from two years study it appears that nitrogen fertilization of Scots pine or balsam fir in Christmas tree plantations is not necessary as growth or needle quality is not enhanced.

Table 1: Needle data for Scots pine at North Battleford.

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	9.2	20	5	0.21	9.1	5.3	70
2	14	19	7	0.29	9.6	4.4	50
3	29	23	6	0.23	10	4.5	85
4	39.9	19	6	0.26	8.8	3.4	60
Check	7.4	23	6	0.26	10.6	6	89

Table 2: Needle data for Scots pine at Kenaston

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	13.2	21	9	0.27	8.5	4.1	45
2	26.3	23	9	0.23	8.6	4.2	50
3	28.8	24	6	0.16	7.9	4	55
4	56.3	21	8	0.17	8.5	4.3	65
Check	8.3	21	9	0.21	8.6	3.5	55

Table 3: Needle data for Scots pine at Indian Head

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
1	13.5	25	9	0.38	9.7	4	75
2	36.1	26	8	0.3	9.5	4	85
3	44.8	27	10	0.35	10	4.9	80
4	156.2	25	9	0.31	9.7	5.1	80
Check	14.4	24	7	0.23	9.1	4.3	85

Table 4: Needle data for Balsam Fir at North Battleford

Trt	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Tissue Nitrogen (%)	Needle Colour (%)
1	2.5	21	7	0.09	2.3	0.59	1.9	60
2	17.3	18	7	0.13	2.5	0.67	2	60
3	27.4	15	7	0.11	2.4	0.64	2.2	50
4	70.2	19	7	0.11	2.4	0.73	2.1	45
Check	3.2	21	6	0.09	2.4	0.53	1.9	50

Comparison of needle characteristics for Scots pine trees at North Battleford, Kenaston and Indian Head indicated that trees at Indian had greater numbers of lateral and terminal buds and a higher percentage of trees with dark green needle colour (Table 5). The trees at the Indian Head site originated were a selected strain of Scots pine developed at the PFRA Shelterbelt Centre specifically for Christmas tree production, whereas the trees at the other sites are of different origins.

Table5: Comparison of soil and needle data for Scots pine at North Battleford, Kenaston and Indian Head

Site	Soil N (ppm)	Lateral Buds (No.)	Terminal Buds (No.)	Terminal Bud Wt (g)	Needle Length (cm)	Needle Weight (g)	Needle Colour (%)
North Battleford	19.9	21	6	0.25	9.6	4.7	71
Kenaston	26.6	22	8	0.21	8.4	4	54
Indian Head	53	25	9	0.31	9.6	4.5	81

Recommendations and Conclusions

1. Foliage characteristics including needle colour were not significantly or consistently better for trees that had been fertilized.

2. Nitrogen fertilization did not significantly increase lengths of terminals or other shoots of trees growing at any of the sites.

3. There was variation in growth and foliage characteristics of individual trees and between sites. Part of the variation was probably related to differences in soil drainage and compaction between and within plantations. Variations were also probably related to genetic differences between trees and nitrogen fertilization will not overcome all of that variation. Genetic selection of progeny from specific locations, individual mother trees and/or individual trees is required to enhance overall appearance of foliage. This work is under way in this project.

4. Excessive (>100kg/ha) applications of nitrogen can result in mortality of young seedlings. Heavy application of nitrogen had no adverse effects on trees one metre or larger.

5. Fertilization does not appear to be worthwhile on Christmas plantations established on agricultural soils.

Indications for Further Development

The initial results from the nutrition phase of the project suggest that nitrogen fertilizer application is not required. The tree improvement phase will continue in the winter of 1999 with additional grafting of selected Scots pine and balsam fir and establishment of seed orchards at Meeting Lake PFRA pasture and Henribourg.

Information Sharing

A review of the project was presented to the annual Saskatchewan Christmas Tree Growers Association Field day held at Prince Albert in August, 1998. A news release was prepared by Saskatchewan Agriculture and Food. The project was described in a news article published in the Western Producer.

Project Success and Relationship with the Objectives

Results for the nutrition study have been reviewed and indicate that nitrogen fertilization of balsam fir and Scots pine is not warranted.

A total of 250 Scots pine seedlings have been selected for establishment of a seedling seed orchard and 20 superior trees selected for vegetative propagation (grafting) and planting in a clonal seed orchard. A total of 200 superior balsam fir are being grafted for planting in a clonal seed orchard. Seed orchard sites have been selected and prepared for planting in the spring of 1999.

Appendix 1: Fertility Data

1. North Battleford Scots Pine Fertility

Rep	Trt	Lateral Buds	Terminal Buds	Weight Term.Buds	Needle Length	Needle Wt.
1	3	19.2	4.6	0.304	6.96	2.78
1	4	22.2	6.4	0.254	9.54	3.32
1	5	19.2	8	0.35	10.22	3.84
1	1	21.6	5.4	0.26	10.48	5.93
1	2	14.4	5.6	0.156	10.42	5.93
2	5	17.8	3.6	0.224	6.8	2.98
2	2	22.6	5.4	0.368	9.58	5.46
2	3	20.2	6.8	0.27	10.04	4.47
2	1	27.25	6	0.2575	11.675	4.23
2	4	22	6.6	0.29	10.54	6.32
3	5	15.8	4.2	0.234	7.64	2.98
3	2	27.6	5.6	0.146	10.14	6.00
3	4	24.4	8.2	0.134	9.82	2.98
3	3	18.8	8.2	0.416	10.8	4.88
3	1	14.8	8.2	0.332	9.78	7.16
4	2	14.4	3.4	0.182	6.32	3.91
4	1	28.2	5.2	0.208	10.32	6.80
4	3	17.6	6.8	0.196	10.6	5.46
4	4	22.8	4.4	0.232	10.1	5.40
4	5	23.2	6.6	0.254	10.44	3.94

TRT	NO3-N
1	2.34
2	1.97
3	29.44
4	42.83
5	45.63
1	4.10
2	3.14
3	5.24
4	11.98
5	94.72

2. Kenaston Scots Pine Fertility

Rep	Trt	Lateral Buds	Terminal Buds	Weight Term.Buds	Needle Length	Needle Wt.	Soil NO3-N
1	3	17.6	5.8	0.202	8.98	4.87	29.96
1	4	28	6.2	0.15	8.48	4.19	25.15
1	5	15.2	7.4	0.216	9.02	3.68	41.41
1	1	20.4	7.4	0.116	8.94	3.1	8.42
1	2	17.6	13.6	0.376	9.44	4.04	10.76
2	5	23.2	7.2	0.184	9.24	4.62	
2	2	21.8	6.4	0.156	8.88	5.64	
2	3	21.8	7	0.196	9.4	5.63	
2	1	20.6	10	0.282	9.76	4.34	
2	4	15.8	7.4	0.156	8.34	4.61	
3	5	30.6	7	0.094	8.04	4.82	71.23
3	2	28.8	10.2	0.304	7.86	3.37	15.71
3	4	25.2	4.6	0.108	7.08	3.42	32.49
3	3	25.6	17	0.296	8.14	2.98	22.71
3	1	24.4	10.6	0.228	7.74	4.53	8.26
4	2	15.6	6	0.244	7.8	3.43	
4	1	20.6	9.2	0.2	8.02	2.16	
4	3	27.6	5.8	0.216	7.86	3.44	
4	4	26.2	6.2	0.214	7.54	3.61	
4	5	16.6	9.2	0.174	7.88	3.93	

3. Indian Head Scots Pine Fertility

Rep	Trt	Terminal Buds	Wt term Buds	Needle length	Needle Wt.	Lateral Buds	Soil NO3-N
1	3	5.2	0.14	8.3	3.68	26.6	36.13
1	4	10.2	0.29	10.1	6.88	30	44.84
1	5	4.8	0.26	9.7	4.55	26.6	156.24
1	1	6.8	0.23	8.6	3.72	20.6	14.41
1	2	14.4	0.52	9.2	3.78	28.6	13.46
2	5	12.2	0.24	9.2	4.42	27.6	
2	2	9.6	0.47	9.9	3.83	25	
2	3	7.6	0.29	9.8	4.38	24	
2	1	5.4	0.17	9.1	4.34	24.2	
2	4	8.4	0.22	8.6	3.17	28.6	
3	5	6.2	0.29	9.8	5.86	21.6	
3	2	6.6	0.20	9.8	3.83	21.6	
3	4	11.8	0.43	10.5	5.47	26.4	
3	3	13.8	0.46	10.3	4.03	26.6	
3	1	7.4	0.21	9.5	4.80	22	
4	2	6.8	0.36	9.9	4.68	25.6	
4	1	8	0.32	9.2	4.38	27.6	
4	3	6.2	0.33	9.5	3.95	25.8	
4	4	10.2	0.47	10.6	4.19	24.8	
4	5	11.4	0.45	10.1	5.47	25	

4. North Battleford Balsam Fir

Rep	Trt	Lateral Buds	Terminal Buds	Wt.Term.Buds	Needle Length	Needle Wt.	Tissue N (%)
1	1	18	6.8	0.068	2.56	0.55	2.1
1	2	18.2	5.8	0.068	2.44	0.66	2.1
1	3	18.6	7.2	0.126	2.56	0.75	1.9
1	4	13.8	4.8	0.06	2.34	0.43	2.3
1	5	20.6	10.2	0.11	2.5	0.71	1.9
2	5	15.2	6.6	0.114	2.7	0.86	2.0
2	2	17.6	4.6	0.066	2.44	0.62	1.8
2	3	13.6	7	0.128	2.6	0.72	2.1
2	1	13.6	5.8	0.078	2.18	0.56	1.9
2	4	12.4	5.8	0.11	2.56	0.73	2.3
3	5	16.6	5.8	0.08	2.04	0.56	2.0
3	2	30.4	8.4	0.096	2.2	0.50	1.9
3	4	19	10.6	0.154	2.4	0.67	2.0
3	3	24.8	9.4	0.156	2.5	0.57	2.1
3	1	24	7.8	0.14	2.34	0.50	1.9
4	2	15.8	8.2	0.164	2.22	0.60	2.0
4	1	29.4	5	0.09	2.44	0.51	1.6
4	3	13	6.4	0.124	2.46	0.63	1.9
4	4	15.4	7.6	0.138	2.5	0.74	2.2
4	5	22.4	6.6	0.122	2.44	0.79	2.3

TRT	Soil NO3-N
1	13.43
2	15.12
3	22.38
4	32.47
5	46.85
1	1.37
2	3.25
3	5.58
4	25.48
5	33.01

Appendix 2: Needle Colour Data

1. North Battleford Balsam Fir

Trt 1	Trt 2	Trt 3	Trt 4	Trt 5
5 GY 3/4	5 GY 3/4	5 GY 3/4	5 GY 4/6	7.5GY4/4
7.5GY3/4	7.5GY3/4	5 GY 3/4	5 GY 3/4	7.5GY4/4
7.5GY3/4	7.5GY3/4	5 GY 4/4	7.5GY3/4	7.5GY4/4
7.5GY3/4	7.5GY4/4	5 GY 4/6	5 GY 4/4	7.5GY4/4
7.5GY3/4	7.5GY4/4	7.5GY4/4	7.5GY4/4	7.5GY3/4
7.5GY3/4	5 GY 4/6	5 GY 4/6	5 GY 4/4	7.5GY3/4
5 GY 4/6	5 GY 3/4	7.5GY3/4	7.5GY3/4	7.5GY4/4
5 GY 4/4	5 GY 4/4	5 GY 4/4	7.5GY3/4	7.5GY3/4
7.5GY3/4	5 GY 4/4	7.5GY4/4	7.5GY3/4	5 GY 3/4
7.5GY4/4	5 GY 3/4	7.5GY3/4	7.5GY3/4	5 GY 4/6
5 GY 4/6	7.5GY4/4	5 GY 4/6	7.5GY4/4	7.5GY3/4
5 GY 4/4	5 GY 4/6	7.5GY3/4	7.5GY4/4	5 GY 4/4
5 GY 4/6	7.5GY4/4	7.5GY3/4	7.5GY4/4	7.5GY4/4
5 GY 4/6	5 GY 4/6	7.5GY3/4	7.5GY4/4	5 GY 4/6
5 GY 4/4	5 GY 4/6	7.5GY4/4	5 GY 4/6	5 GY 3/4
5 GY 4/4	7.5GY4/4	7.5GY3/4	5 GY 4/4	5 GY 3/4
5 GY 4/4	5 GY 4/6	7.5GY4/4	7.5GY4/4	7.5GY4/4
5 GY 4/8	5 GY 4/4	5 GY 3/4	5 GY 4/4	7.5GY3/4
5 GY 4/6	7.5GY4/4	5 GY 4/6	7.5GY4/4	5 GY 4/6
7.5GY3/4	7.5GY4/4	5 GY 4/4	5 GY 4/6	5 GY 4/4

2. Kenaston Scots Pine

Trt 1	Trt 2	Trt 3	Trt 4	Trt 5
5 GY 4/8	5 GY 4/6	5 GY 4/6	7.5GY4/4	7.5GY4/4
7.5GY4/4	5 GY 4/8	5 GY 4/8	7.5GY4/4	7.5GY4/4
7.5GY4/6	5 GY 4/6	7.5GY4/6	7.5GY4/4	7.5GY4/4
5 GY 4/6	7.5GY4/4	5 GY 4/6	7.5GY4/6	5 GY 4/6
7.5GY4/4	5 GY 4/8	5 GY 4/6	5 GY 4/8	5 GY 4/6
7.5GY4/4	7.5GY4/4	5 GY 4/6	7.5GY4/4	7.5GY4/6
7.5GY4/4	7.5GY4/6	7.5GY4/4	5 GY 4/6	5 GY 4/6
7.5GY4/4	7.5GY4/4	7.5GY4/4	7.5GY4/6	7.5GY4/6
5 GY 4/6	7.5GY4/4	7.5GY4/6	7.5GY4/4	7.5GY4/4
7.5GY4/4	7.5GY4/4	7.5GY4/4	7.5GY4/4	7.5GY4/6
7.5GY 4/4	7.5GY 4/4	5 GY 4/8	7.5GY 4/6	5 GY 4/4
7.5GY 4/4	5 GY 4/6	5 GY 4/6	5 GY 4/4	5 GY 4/8
7.5GY 4/4	5 GY 4/8	5 GY 4/6	5 GY 5/6	7.5GY 4/4
5 GY 4/4	5 GY 5/8	5 GY 5/6	7.5GY 4/4	7.5GY 4/4
5 GY 4/6	7.5GY 4/4	7.5GY 4/4	5 GY 4/6	7.5GY 4/4
5 GY 4/8	7.5GY 4/4	7.5GY 4/4	5 GY 4/6	7.5GY 4/6
5 GY 4/6	5 GY 4/6	7.5GY 4/4	5 GY 4/6	7.5GY 4/4
7.5GY 4/4	5 GY 4/6	7.5GY 4/4	5 GY 4/8	7.5GY 4/6
5 GY 4/6	5 GY 4/8	7.5GY 4/4	7.5GY 5/4	5 GY 4/6
5 GY 4/8	5 GY 4/6	5 GY 4/6	5 GY 4/6	5 GY 4/8

3. North Battleford Scots Pine

Trt 1	Trt 2	Trt 3	Trt 4	Trt 5
7.5GY 3/4	7.5GY 3/4	5 GY 4/6	5 GY 4/8	5 GY 4/6
5 GY 4/6	7.5GY 4/4	5 GY 4/8	7.5GY 4/4	7.5GY 4/6
7.5GY 4/4	7.5GY 3/4	5 GY 4/6	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	5 GY 4/6	2.5GY 5/6	7.5GY 4/4	7.5GY 4/6
7.5GY 4/4	7.5GY 4/4	5 GY 4/6	7.5GY 4/6	7.5GY 4/4
7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	7.5GY 4/4	5 GY 4/6
	7.5GY 4/6	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	7.5GY 4/4	5 GY 4/8	7.5GY 4/4	5 GY 4/6
7.5GY 4/4	7.5GY 4/4	5 GY 4/6	7.5GY 4/4	5 GY 5/6
7.5GY 4/4	5 GY 4/6	5 GY 4/4	7.5GY 4/4	7.5GY 4/6
7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	5 GY 4/6	5 GY 4/6
7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	7.5GY 4/4	5 GY 4/6
5 GY 4/6	7.5GY 4/6	7.5GY 4/4	5 GY 4/8	5 GY 4/6
7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	5 GY 4/6	5 GY 4/8	7.5GY 4/4	7.5GY 4/4
7.5GY 4/6	2.5GY 5/6	5 GY 4/6	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	5 GY 4/8	7.5GY 4/4	7.5GY 4/4	5 GY 4/6
7.5GY 4/4	5 GY 4/8	7.5GY 4/4	7.5GY 3/4	7.5GY 4/4

4. Indian Head Scots Pine

Trt 1	Trt 2	Trt 3	Trt 4	Trt 5
7.5GY 4/6	7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	7.5GY 4/6
7.5GY 4/4	7.5GY 4/4	7.5GY 5/6	7.5GY 4/4	7.5GY 4/6
7.5GY 4/6	7.5GY 4/4	7.5GY 4/6	7.5GY 5/4	7.5GY 5/4
7.5GY 4/4	7.5GY 5/4	7.5GY 4/4	7.5GY 4/6	7.5GY 4/6
7.5GY 4/6	7.5GY 5/4	7.5GY 5/6	7.5GY 4/6	7.5GY 4/6
7.5GY 4/6	7.5GY 4/4	7.5GY 4/6	7.5GY 5/6	7.5GY 4/6
7.5GY 4/6	7.5GY 4/6	7.5GY 4/4	7.5GY 4/6	7.5GY 5/6
7.5GY 4/6	7.5GY 5/4	7.5GY 4/6	7.5GY 5/4	7.5GY 4/6
7.5GY 4/6	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4	7.5GY 4/4
7.5GY 4/4	7.5GY 4/4	7.5GY 4/6	7.5GY 4/4	7.5GY 5/4
7.5GY 4/4	7.5GY 5/4	7.5GY 5/4	7.5GY 4/4	7.5GY 4/6
7.5GY 4/6	7.5GY 4/4	7.5GY 5/4	7.5GY 5/4	7.5GY 4/4
7.5GY 5/4	7.5GY 4/4	7.5GY 5/4	7.5GY 4/4	7.5GY 4/4
7.5GY 5/4	5.0GY 5/8	7.5GY 4/6	7.5GY 4/4	7.5GY 5/6
7.5GY 4/6	7.5GY 5/6	7.5GY 5/4	7.5GY 4/4	7.5GY 4/6
7.5GY 4/4	5 GY 4/6	7.5GY 4/4	5 GY 4/8	5 GY 4/6
2.5GY 5/6	5 GY 4/8	5 GY 4/8	2.5GY 5/6	7.5GY 4/4
2.5GY 5/6	5 GY 4/6	7.5GY 4/4	7.5GY 4/4	5 GY 4/6
7.5GY 4/4	5 GY 4/6	5 GY 5/8	2.5GY 5/6	2.5GY 5/6
5 GY 4/8	7.5GY 4/4	5 GY 4/8	5 GY 5/4	2.5GY 5/8

Appendix 3: Statistical Analysis for Fertility Project

1. Scots Pine Fertility Kenaston Site - 1998

Analysis of Variance for C3 - No. Of Lateral Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	157.17	157.17	52.39	2.48	0.111
C2	4	24.59	24.59	6.15	0.29	0.878
Error	12	253.41	253.41	21.12		
Total	19	435.17				

Analysis of Variance for C4 - No. Of Terminal Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	20.214	20.214	6.738	0.68	0.583
C2	4	28.328	28.328	7.082	0.71	0.600
Error	12	119.416	119.416	9.951		
Total	19	167.958				

Analysis of Variance for C5 - Weight of Terminal Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.000869	0.000869	0.000290	0.06	0.981
C2	4	0.033919	0.033919	0.008480	1.70	0.214
Error	12	0.059825	0.059825	0.004985		
Total	19	0.094613				

Analysis of Variance for C6 - Needle Length

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	7.9010	7.9010	2.6337	37.72	0.000
C2	4	1.6139	1.6139	0.4035	5.78	0.008
Error	12	0.8378	0.8378	0.0698		
Total	19	10.3527				

Analysis of Variance for C7 - Needle Weight

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	7.1875	7.1875	2.3958	4.62	0.023
C2	4	1.4179	1.4179	0.3545	0.68	0.617
Error	12	6.2200	6.2200	0.5183		
Total	19	14.8253				

Means

	C3		C4		C5	
C2	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	21.5000	2.29770	9.3000	1.57729	0.2065	0.03530
2	20.9500	2.29770	9.0500	1.57729	0.2700	0.03530
3	23.1500	2.29770	8.9000	1.57729	0.2275	0.03530
4	23.8000	2.29770	6.1000	1.57729	0.1570	0.03530
5	21.4000	2.29770	7.7000	1.57729	0.1670	0.03530

	C6		C7	
C2	Mean	Stdev	Mean	Stdev
1	8.6150	0.13211	3.5325	0.35998
2	8.4950	0.13211	4.1200	0.35998
3	8.5950	0.13211	4.2300	0.35998
4	7.8600	0.13211	3.9575	0.35998
5	8.5450	0.13211	4.2625	0.35998

2. Scots Pine Fertility - North Battleford Site 1998

General Linear Model

Analysis of Variance for **C3 - No. of Lateral Buds**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	19.93	19.93	6.64	0.31	0.818
C2	4	66.39	66.39	16.60	0.77	0.564
Error	12	257.74	257.74	21.48		
Total	19	344.05				

Analysis of Variance for **C4 - No. of Terminal Buds**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	6.944	6.944	2.315	0.96	0.441
C2	4	6.848	6.848	1.712	0.71	0.599
Error	12	28.816	28.816	2.401		
Total	19	42.608				

Analysis of Variance for **C5 - Weight of Terminal Buds**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.012321	0.012321	0.004107	0.64	0.602
C2	4	0.017710	0.017710	0.004427	0.69	0.611
Error	12	0.076718	0.076718	0.006393		
Total	19	0.106748				

Analysis of Variance for **C6 - Needle Length**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.123	0.123	0.041	0.02	0.997
C2	4	8.016	8.016	2.004	0.73	0.586
Error	12	32.772	32.772	2.731		
Total	19	40.912				

Analysis of Variance for **C7 - Needle Weight**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	1.407	1.407	0.469	0.29	0.830
C2	4	15.527	15.527	3.882	2.43	0.105
Error	12	19.197	19.197	1.600		
Total	19	36.131				

Means

	..... C3		..... C4		..... C5	
C2	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	22.9625	2.31724	6.2000	0.77481	0.2644	0.03998
2	19.7500	2.31724	5.0000	0.77481	0.2130	0.03998
3	18.9500	2.31724	6.6000	0.77481	0.2965	0.03998
4	22.8500	2.31724	6.4000	0.77481	0.2275	0.03998
5	19.0000	2.31724	5.6000	0.77481	0.2655	0.03998

	..... C6		..... C7	
C2	Mean	Stdev	Mean	Stdev
1	10.5637	0.82629	6.0300	0.63240
2	9.1150	0.82629	5.3250	0.63240
3	9.6000	0.82629	4.3975	0.63240
4	10.0000	0.82629	4.5050	0.63240
5	8.7750	0.82629	3.4350	0.63240

3.Scots Pine Fertility Study - Indian Head Site 1998

Analysis of Variance for **C4 - # Terminal Buds**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	2.07	2.07	0.69	0.06	0.979
C2	4	24.02	24.02	6.00	0.54	0.708
Error	12	132.78	132.78	11.06		
Total	19	158.87				

Analysis of Variance for **C5 - Weight of Terminal Buds**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.03562	0.03562	0.01187	0.90	0.468
C2	4	0.05425	0.05425	0.01356	1.03	0.430
Error	12	0.15751	0.15751	0.01313		
Total	19	0.24737				

Analysis of Variance for **C6 - Needle Length**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	2.3295	2.3295	0.7765	2.60	0.101
C2	4	1.6280	1.6280	0.4070	1.36	0.304
Error	12	3.5880	3.5880	0.2990		
Total	19	7.5455				

Analysis of Variance for **C7 - Needle Weight**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	1.5487	1.5487	0.5162	0.68	0.580
C2	4	4.0245	4.0245	1.0061	1.33	0.314
Error	12	9.0762	9.0762	0.7564		
Total	19	14.6495				

Analysis of Variance for C8 - # of Lateral Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	23.088	23.088	7.696	1.31	0.318
C2	4	30.548	30.548	7.637	1.30	0.326
Error	12	70.732	70.732	5.894		
Total	19	124.368				

Means

	C4		C5		C6	
C2	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	6.9000	1.66320	0.2325	0.05728	9.1000	0.27340
2	9.3500	1.66320	0.3875	0.05728	9.7000	0.27340
3	8.2000	1.66320	0.3050	0.05728	9.4750	0.27340
4	10.1500	1.66320	0.3525	0.05728	9.9500	0.27340
5	8.6500	1.66320	0.3100	0.05728	9.7000	0.27340

	C7		C8	
C2	Mean	Stdev	Mean	Stdev
1	4.3100	0.43484	23.6000	1.21391
2	4.0300	0.43484	25.2000	1.21391
3	4.0100	0.43484	25.7500	1.21391
4	4.9275	0.43484	27.4500	1.21391
5	5.0750	0.43484	25.2000	1.21391

4.Balsam Fir Fertility - North Battleford,1998

Analysis of Variance for C3 - Lateral Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	184.60	184.60	61.53	3.07	0.069
C2	4	95.01	95.01	23.75	1.19	0.366
Error	12	240.46	240.46	20.04		
Total	19	520.07				

Analysis of Variance for C4 - Terminal Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	15.496	15.496	5.165	1.74	0.211
C2	4	3.452	3.452	0.863	0.29	0.878
Error	12	35.524	35.524	2.960		
Total	19	54.472				

Analysis of Variance for C5 - Weight of Terminal Buds

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.0060688	0.0060688	0.0020229	2.41	0.118
C2	4	0.0039288	0.0039288	0.0009822	1.17	0.372
Error	12	0.0100712	0.0100712	0.0008393		
Total	19	0.0200688				

Analysis of Variance for **C6 - Needle Length**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.12406	0.12406	0.04135	1.79	0.202
C2	4	0.09448	0.09448	0.02362	1.02	0.434
Error	12	0.27704	0.27704	0.02309		
Total	19	0.49558				

Analysis of Variance for **C7 - Needle Weight**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.050820	0.050820	0.016940	2.05	0.160
C2	4	0.090970	0.090970	0.022743	2.76	0.078
Error	12	0.099030	0.099030	0.008253		
Total	19	0.240820				

Analysis of Variance for **C8 - Tissue Nitrogen**

Source	DF	Seq SS	Adj SS	Adj MS	F	P
C1	3	0.01750	0.01750	0.00583	0.20	0.894
C2	4	0.23800	0.23800	0.05950	2.04	0.152
Error	12	0.35000	0.35000	0.02917		
Total	19	0.60550				

Means

	C3		C4		C5	
C2	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	21.2500	2.23821	6.3500	0.86028	0.0940	0.01449
2	20.5000	2.23821	6.7500	0.86028	0.0985	0.01449
3	17.5000	2.23821	7.5000	0.86028	0.1335	0.01449
4	15.1500	2.23821	7.2000	0.86028	0.1155	0.01449
5	18.7000	2.23821	7.3000	0.86028	0.1065	0.01449

	C6		C7		C8	
C2	Mean	Stdev	Mean	Stdev	Mean	Stdev
1	2.3800	0.07597	0.5300	0.04542	1.8750	0.08539
2	2.3250	0.07597	0.5950	0.04542	1.9500	0.08539
3	2.5300	0.07597	0.6675	0.04542	2.0000	0.08539
4	2.4500	0.07597	0.6425	0.04542	2.2000	0.08539
5	2.4200	0.07597	0.7300	0.04542	2.0500	0.08539

AFIF Progress Report, January 1 - June 30, 1998
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

Summary

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards. During this reporting period the project concentrated on the studying nutrition requirements of Scots pine and balsam fir. Four sites were selected for the study and the effects of five levels of nitrogen fertilizer on tree growth were compared. High rates of nitrogen caused mortality in balsam fir trees. Preliminary results indicated that application of nitrogen had only marginal effects on growth of balsam fir and Scots pine. This portion of the project will be repeated in 1998 to confirm results. Selection and propagation of superior trees for the seed orchards will begin February, 1998.

Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality. Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more.

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry. And to provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities, January 1 - June 30, 1998

The tree improvement phase of the project was initiated in February, 1998 with the selection of superior balsam fir phenotypes and propagation of the clones by grafting. Native stands of balsam fir at Candle Lake, Weyakwin, Meadow Lake were sampled. Grafting success was 60 percent. Two hundred grafted balsam fir trees are being maintained in a shade house at the PFRA Shelterbelt Centre and will be field planted in a seed orchards in 1999. Five hundred Scots pine trees with superior needle colour and form were selected from a seedling population of Scots pine at the Shelterbelt Centre. The trees were planted in a holding nursery until they can be established in a seed orchard in 1999. Five sources of Scots pine are being compared in a replicated test at the Shelterbelt Centre. These sources are currently being used for Christmas tree plantings in North and South Dakota. The trees will be evaluated for hardiness, needle colour and form.

Fertility levels for Scots pine and balsam fir growing in existing orchards continues to be

evaluated. Maximizing growth and high quality trees are important factors in economic sustainability of Christmas tree production. Tree quality is dependent on having vigorous, healthy trees with green needle colour. Conifers normally respond to applications of nitrogen fertilizer, but show limited or no improved growth following application of phosphorous or potassium. In this phase of the project we concentrated on determining optimal levels of nitrogen that will result in maximum growth and darkest green needle colour. In addition, we will determine the optimal concentration of nitrogen in foliage of balsam fir and Scots pine by monitoring changes in foliar nitrogen content following fertilization. This will help explain growth responses and provide a diagnostic index that will be useful when predicting the response potential of unfertilized trees.

Test sites were located at Christmas tree orchards near Prince Albert, North Battleford, Kenaston and Indian Head, Saskatchewan. Five levels of nitrogen fertilizer applied in the spring (four fertilizer treatments plus a non-fertilized check) to balsam fir at Prince Albert and North Battleford and Scots pine trees at all the test sites. For each species the study was arranged in a Randomized Complete Block design with four, five tree replications per treatment. A total of 100 trees per species per site were used in the study. The plot means of all parameters were compared using ANOVA and where significant treatment effects were detected means were separated using Duncan's Multiple Range test.

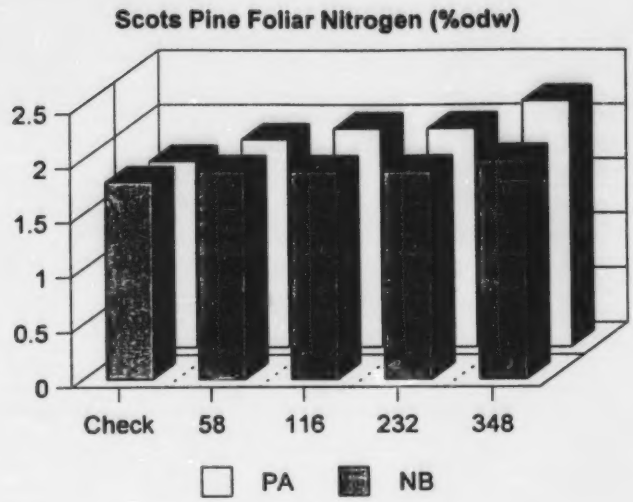
1. 58g Nitrogen/Tree
2. 116g Nitrogen/Tree
3. 232g Nitrogen/Tree
4. 348g Nitrogen/Tree
5. Non-fertilized Check

The nitrogen (34-0-0) fertilizer was broadcast in a 1 m diameter area around each tree in May.

All trees were measured in October of 1997. The lengths of the 1997 internode, the current leader, and the most southerly lateral shoot of the top whorl were measured and the lateral buds on the terminal leader counted. A composite twig sample consisting of the distal 2 to 4 cm portion of the most northerly lateral shoot of each tree was collected and the length of 100 needles and the number and dry weight of buds on each twig terminal determined. Foliage samples were obtained by clipping the distal 2-4 cm of the most northerly lateral shoot of the top whorl of two trees per plot. The samples were dried at 70°C and then ground and shipped to the soil testing lab for determination of nitrogen concentration (% of oven-dry weight).

Results

Growth data was analysed for each species and test site. Growth was not affected by application of nitrogen, except that the highest rate of nitrogen resulted in high mortality with the balsam fir at Prince Albert. The balsam fir seedlings at this site were considerably smaller than at North Battleford and consequently the rates selected for the study were too high and burned the seedlings. Drought conditions during the growing season may have reduced the effectiveness of the fertilizer applications. The tissue analysis has not been completed.



Indications for Further Development

The initial results from the nutrition phase of the project suggest that further refinement of fertility application is required. The fertility study will continue in 1998 with greater emphasis on balsam. The tree improvement phase will be initiated in the winter of 1998 and will be reported on in the July 1, 1998 report.

Information Sharing

A review of the project was presented to the annual Saskatchewan Christmas Tree Growers Association Field day held at Indian Head in August, 1997.

Project Success and Relationship with the Objectives

Preliminary results for the nutrition study have been reviewed and indicate that further study is required before specific conclusions can be drawn.

AFIF Progress Report, May 1 - December 31, 1997
Improved Trees and Technology for Christmas Tree Production in Saskatchewan
Project No. 96000377

Summary

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry and to provide guidelines on fertility management for coniferous species used in Christmas tree orchards. During this reporting period the project concentrated on the studying nutrition requirements of Scots pine and balsam fir. Four sites were selected for the study and the effects of five levels of nitrogen fertilizer on tree growth were compared. High rates of nitrogen caused mortality in balsam fir trees. Preliminary results indicated that application of nitrogen had only marginal effects on growth of balsam fir and Scots pine. This portion of the project will be repeated in 1998 to confirm results. Selection and propagation of superior trees for the seed orchards will begin February, 1998.

Technical Report

1. Background and Objectives

The Christmas tree industry is relatively new to Saskatchewan. It is difficult for growers to obtain high quality plant material adapted to Saskatchewan growing conditions. Varieties developed and used in other regions of North America will not survive or result in poor quality trees. Availability of improved plant material and new varieties that grow well in Saskatchewan will increase annual production of trees grown in the province, reduce labour costs giving Saskatchewan growers a competitive advantage over less fresh and lower quality trees that are imported into the province and also place Saskatchewan growers in a better position to enter into the export market. Seed orchards will provide growers with a consistent supply of high quality seedlings at a reasonable cost and reduce the reliance on imported seed of questionable adaptability and quality. Growers do not have access to fertilizer guidelines for Christmas tree species growing under Saskatchewan growing conditions. Fertility recommendations will assist growers in making the proper management decisions and increase productivity, improve tree quality and reduce production costs by shortening rotation time by one year or more.

The objective of the project is to provide improved seed sources of balsam fir and Scots pine for the Saskatchewan Christmas tree industry. And to provide guidelines on fertility management for coniferous species used in Christmas tree orchards.

2. Project Activities, May 1 - December 31, 1997

The tree improvement phase of the project is being initiated in February, 1998 with the selection of superior phenotypes and propagation of the clones by grafting. Each Christmas tree plantation in Saskatchewan will be surveyed and scion wood collected from the best trees at each site.

Phase one of the project concentrated on determining optimum fertility levels for Scots pine and balsam fir growing in existing orchards. Maximizing growth and high quality trees are important factors in economic sustainability of Christmas tree production. Tree quality is dependent on having vigorous, healthy trees with green needle colour. Conifers normally respond to applications of nitrogen fertilizer, but show limited or no improved growth following application of phosphorous or potassium. In this phase of the project we concentrated on determining optimal levels of nitrogen that will result in maximum growth and darkest green needle colour. In addition, we will determine the optimal concentration of nitrogen in foliage of balsam fir and Scots pine by monitoring changes in foliar nitrogen content following fertilization. This will help

explain growth responses and provide a diagnostic index that will be useful when predicting the response potential of unfertilized trees.

Test sites were located at Christmas tree orchards near Prince Albert, North Battleford, Kenaston and Indian Head, Saskatchewan. Five levels of nitrogen fertilizer applied in the spring (four fertilizer treatments plus a non-fertilized check) to balsam fir at Prince Albert and North Battleford and Scots pine trees at all the test sites. For each species the study was arranged in a Randomized Complete Block design with four, five tree replications per treatment. A total of 100 trees per species per site were used in the study. The plot means of all parameters were compared using ANOVA and where significant treatment effects were detected means were separated using Duncan's Multiple Range test.

1. 58g Nitrogen/Tree
2. 116g Nitrogen/Tree
3. 232g Nitrogen/Tree
4. 348g Nitrogen/Tree
5. Non-fertilized Check

The nitrogen (urea) fertilizer was broadcast in a wide band beneath the drip line of each tree in May.

All trees were measured in October of 1997. The lengths of the 1997 internode, the current leader, and the most southerly lateral shoot of the top whorl were measured and the lateral buds on the terminal leader counted. A composite twig sample consisting of the distal 2 to 4 cm portion of the most northerly lateral shoot of each tree was collected and the length of 100 needles and the number and dry weight of buds on each twig terminal determined. Foliage samples were obtained by clipping the distal 2-4 cm of the most northerly lateral shoot of the top whorl of two trees per plot. The samples were dried at 70°C and then ground and shipped to the soil testing lab for determination of nitrogen concentration (% of oven-dry weight).

Results

Growth data was analysed for each species and test site. Growth was not affected by application of nitrogen, except that the highest rate of nitrogen resulted in high mortality with the balsam fir at Prince Albert. The balsam fir seedlings at this site were considerably smaller than at North Battleford and consequently the rates selected for the study were too high and burned the seedlings. Drought conditions during the growing season may have reduced the effectiveness of the fertilizer applications. The tissue analysis has not been completed.

Indications for Further Development

The initial results from the nutrition phase of the project suggest that further refinement of fertility application is required. The fertility study will be repeated in 1998 will greater emphasis placed on application rates. The tree improvement phase will be initiated in the winter of 1998 and will be reported on in the July 1, 1998 report.

Information Sharing

A review of the project was presented to the annual Saskatchewan Christmas Tree Growers Association Field day held at Indian Head in August, 1997.

Project Success and Relationship with the Objectives

Preliminary results for the nutrition study have been reviewed and indicate that further study is

required before specific conclusions can be drawn.

Personnel

The PFRA Shelterbelt Centre was subcontracted ($8000) to conduct the technical aspects of the project. For the period July 9 to December 31, 1997. The Centre employed Patrick Moore to carry out the nutrition portion of the project.

Equipment

No equipment was purchased or rented with project funds.

Appendix 3

Project Handouts

FERTILITY MANAGEMENT FOR CHRISTMAS TREE ORCHARDS

Soil fertility will affect the quantity and quality of Christmas trees in the orchard. The control of orchard fertility can be regarded as a two-stage process: assessment and maintenance. The assessment stage involves determining the fertility status of the site and alleviating any deficiencies. The management stage involves maintaining nutrients at optimal levels for both tree growth and quality.

Assessing Site Fertility

Soil Sampling

Soils in an orchard must be systematically sampled. It is not practicable to try to manage an orchard on an individual-tree basis, nor should a 10 acre orchard be managed as one entity. Therefore, workable management blocks, that can be treated as homogeneous units must be identified. To do this, blocks/areas are identified which can be managed separately. The management blocks are usually determined by some logical subdivision of the orchard such as species, suborchards, or year of establishment within a given species.

Sampling to determine variation in a single orchard block should be done in one year. DO NOT collect a small number of samples and if the variation is high, collect more samples the following year. If samples are collected in year 1, and subsequently the site is disturbed, e.g. cultivated and harrowed, nutrient levels of soil samples collected immediately after the disturbance may be significantly higher than before the disturbance. This nutrient flush is temporary, but still inflates the nutrient levels in the second samples.

It is important to collect samples distributed throughout the sampling area. The following procedure is designed to ensure that the entire area is sampled and that sufficient sample is collected. The major costs arise from processing and analysing the samples, NOT from collecting them. DO NOT CUT CORNERS WHEN COLLECTING SOIL SAMPLES.

1. A minimum of 5 to 10 cores per hectare should be collected. Sampling at 40 m x 40 m equals 6 samples per hectare.

2. Using a soil auger, take cores to a depth of 15 to 20 cm. Small diameter augers, e.g. 2 cm, or larger sizes can be used. THE SAME NUMBER OF SAMPLES SHOULD BE COLLECTED REGARDLESS OF THE SIZE OF THE AUGER.

3. Mix all the samples from each sampling area, removing large roots, clumps of sod, etc. Use a CLEAN container in which to mix the soil. DO NOT use old oil or pesticide pails or similar containers that might contain residues which could contaminate the soil.

4. If a large diameter(10 cm) sampling auger is used, the total amount of soil collected will be much more than is needed for analysis. Mix the soil thoroughly and take a 1 L subsample randomly from the total soil sample.

5. Place each sample separately in a soil sample bag obtained from the soil test laboratory at Saskatoon. Label the bags with waterproof ink, and map the exact locations in the orchard where they were collected. If the blocks have not yet been planted and no permanent reference points are available, the samples must be plotted as closely as possible on maps.

6. Air-dry the samples and store them in a cool, dry, environment until they are shipped to a laboratory for analysis. DO NOT store soil samples in plastic bags.

Sampling for annual fertility assessment should be done in the fall e.g. September to November each year. Samples MUST be collected the same way each year. e.g. the depth to which the sample is collected will influence the nutrient levels.

Assessing Soil Fertility

The three objectives of soil and plant tissue analysis which apply to monitoring Christmas tree orchard fertility are:

1. To determine why a tree exhibits poor growth and/or abnormalities such as discoloration.
2. To detect nutrient deficiencies that inhibit growth in a tree or stand.
3. To control and regulate the nutrient supply to a tree necessary to produce a crop to meet specific objectives of management.

In Christmas tree orchards, it is unacceptable to wait until deficiency symptoms appear. Nutrient deficiencies that might inhibit tree growth and development must be detected before growth is seriously affected. Therefore, the third objective is the most important.

Soil Testing and Analysis

Soils samples are submitted to a reputable soil test lab. It is important that once a lab is selected you continue to use it. DO NOT CHANGES LABS FROM YEAR TO YEAR. After analysing your soil or plant samples the lab will send a detailed report on the fertility status of your field. The lab will normally provide data on soil acidity (pH), organic matter content, cation exchange capacity and soil macronutrients. Interpreting these results can be difficult as most labs have limited information on fertility relationships for tree crops. Table 1 shows target fertility levels for Christmas tree production

Soil Acidity (pH)

Soil acidity (pH), should range between 5.0 and 6.0. At soil pH levels below 5.0, phosphorus availability decreases because of the formation of insoluble complexes with iron and aluminum. The more soluble or available forms of P occur in soils of pH from 5.5 to 7.0. It is very difficult to modify or change soil pH. Application of lime will increase pH but is expensive. Lowering pH of alkaline soils on a large scale is very difficult.

Organic Matter Content

The organic matter content influences the chemical characteristics and moisture holding capacity of the soil. Soils low in organic matter are more susceptible to compaction by machinery than soils with high organic matter content. The level of soil organic matter in the orchard should be between 4 and 5%.

Soil organic matter can be increased through either sowing a grain crop such as fall rye or oats, and plowing it into the soil or through organic amendments such as peat. The increase in organic matter content by additions of peat is difficult to determine reliably. Applying peat at 200 m^3/ha corresponds to a 2-cm thick layer (this would correspond to a 6- to 8-cm thick layer of loose, bulk peat) and would raise the organic matter content by about 0.7% assuming that all was eventually incorporated into the soil.

Regardless of the method used, increasing soil organic matter content is expensive and must be done BEFORE either a cover crop is sown or trees are planted.

Cation Exchange Capacity

The cation exchange capacity (CEC) of a soil is its capacity to hold and exchange positively charged particles (cations) which include the nutrients potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), ammonium (NH_4^+), hydrogen (H^+) and sodium (Na^+). The CEC of a soil is determined primarily from its clay and organic matter contents and should be between 10 and 15 meq/100g.

Soils with a low CEC have a low water holding capacity, and lose N and K to leaching more readily than soils with a high CEC.

Soil Macronutrients

The Soil macronutrients include nitrogen (N), phosphorous (P) and potassium (K). They are required in relatively large quantities by trees. Precise fertility recommendations for Christmas tree orchards in the prairies have not been determined, but can be estimated. The most important macronutrient is nitrogen, it can influence growth and color of trees. Phosphorous contributes to root development and generally is more important during establishment. Applications to established trees is usually not necessary. Potassium is seldom deficient in Saskatchewan soils and not normally a concern.

Assessing Foliar Nutrients Levels

Soil macro- and micronutrient levels vary considerably between sites, depending on parent material, organic matter content, pH, etc. These factors not only affect the quantity of nutrients present in the soil but also their availability to the trees. Therefore, while soil analyses determine the levels of nutrients in the soil, foliar analysis can be done to determine whether or not the trees are actually obtaining adequate supplies.

Research results have shown that there are differences in foliar nutrient levels between trees. To assess tree nutrition through foliar analyses, the number of samples collected must be sufficiently large to mask these genetic differences.

1. For each species/sub-orchard/orchard block, randomly select 50 trees.
2. In September or October (after shoot lignification has ceased), collect one current-year shoot from the upper one-third of the crown of each tree (Table 2). Shoots should be collected from the same position in the crown for all trees (nutrient levels vary with height in the crown e.g., shoot vigour).
3. Combine all the shoots.
4. Ship to the lab as soon as possible.
5. Foliage should be analysed for the macronutrients (N, P, K, Ca, Mg). Suggested foliar nutrient levels are given in Table 3.

Correcting Nutrient Deficiencies and Optimizing Growth

Once soil fertility levels have been determined, measures must be taken to correct any deficiencies. Tables 4 and 5 contains tables for nitrogen and phosphorous cations. Recommendations are provided for nutrients individually. Generally Saskatchewan soils have ample potassium. Fertilizers should be applied in early spring (about the time aspen leaves are opening).

During the early years of tree establishment, tree growth should be optimized. All other factors being equal, vigorous trees can be marketed earlier and have superior quality to small trees. Ferilization is generally required during orchard establishment. Application of nitrogen should be avoided at the time of planting unless foliar nutrient levels are very low, or the rates are kept very low. Fertilization on a yearly basis is seldom required. Applications of nitrogen every other year is usually adequate. Nitrogen can be surface applied, however, unless soils are sandy with low cation exchange capacity phosphorous should be incorporated into the soil.

Table 1. Suggested soil fertility levels for Christmas tree orchards

	Units	Recommended Level[1]
pH	--	5.0 - 7.0
Organic matter	(%)	4.0 - 5.0
Cation exchange capacity	meq/100g	10 - 15
N (nitrogen)	Available N (ppm)	70
P (phosphorous)	Available P (ppm)	75 - 100

[1] Units as given on soils analysis lab report.

Table 2. Foliage sampling for nutrient analysis. The suggested numbers of shoots to be collected, and should provide ample material for most laboratories.

Species	Wt./100[1] needles (g)	Approx. no. needles per 15 cm shoot	Minimum no. shoots required to obtain a 3 g sample oven dry wt
White spruce	0.180 - 0.250	300 - 350	4 - 5
Scots pine	0.500 - 0.600	150 - 175	3 - 4
Red pine	4.000 - 4.500	150 - 175	1 - 2
White pine	0.900 - 1.000	75 - 100	3 - 4

[1] From M.K. Mahendrappa (unpublished data).
[2] Absolute minimum; 10 shoots will not produce the full 3 g.

Table 3. Suggested foliar nutrient levels by species for Christmas tree orchards. Orchard trees can be considered as being adequately supplied with the major elements if foliar levels are maintained within these ranges

	Element (% dry weight)				
Species	N	P	K	Ca	Mg
White spruce	1.3 - 1.7	0.15 - 0.25	0.70 - 0.80	0.20 - 0.30	0.06 - 0.10
Scots pine	1.2 - 1.6	0.15 - 0.20	0.60 - 0.80	0.20 - 0.30	0.06 - 0.10

Table 4. Ammonium Nitrate required for Christmas Trees

Available Nitrogen (ppm)	Amount of Ammonium Nitrate (34-0-0) needed (g/tree)
0	37.5
10	37.5
20	10.5
30	8.3
40	6
50	3.8
60	1.6
70	---
80	---
90	---
100	---

[1] Assumes fertilization is applied in a band (evenly distributed) around each tree. The band should be located approximately half-way between the crown dripline and the stem. Do not DUMP the fertilizer at the base of trees. This can result in root damage and kill small trees.

[2] For new plantings (year 1-3) apply one-half the rate.

Table 5. Triple super phosphate required for Christmas Trees

Available Phosphorus (ppm)	Amount of triple super Phosphorus (0-46-0) needed (g/tree)[1,2]
0	60
10	60
20	50
30	37.5
40	25
50	12.5
60	----
70	----
80	----
90	----
100	----

[1] Assumes fertilizer is applied in a band (evenly distributed) around each tree. The band should be located approximately half-way between the crown dripline and the stem. Phosphorous should be incorporated into the soil. Do not DUMP the fertilizer at the base of the trees. This can result in root damage and possibly kill small trees.

[2] For new plantings (year 1-2) apply one-half the rate.

GRAFTING BALSAM FIR

INTRODUCTION

Grafting is used in tree improvement programs to reproduce exactly the genetic material (genotypes) of selected trees. In addition, to being genetic photocopies, grafts usually retain the physiological age of the original trees and are thus capable of flowering at an earlier age than are seedlings. This is especially beneficial for balsam fir which does not flower at an early age.

The Shelterbelt Centre has been grafting balsam fir for several years and experience has shown this species to be somewhat more difficult to graft than other conifers ie. Scots pine and spruce. This report outlines grafting procedures for balsam fir and is based on experience gained at the Centre and information from other propagation specialists.

SCION COLLECTION

Scion collection must be co-ordinated with grafting to ensure scions are grafted fresh. When collecting scions, take terminals from the upper crown of the tree and make the cut into second year wood. You will make a fresh cut to remove the new growth when you do the graft. A fresh cut (at least ½ " higher than cut at collection time) will result in a better graft union. Scions should be 8 to15cm (3" to 5")long and 3 to 6 cm (1/8" to 1/4") in diameter. Store scions in sealed poly bags (in snow if possible) at -2C until ready to graft. Keeping the scions cold right up until the cut is made will prevent stickiness when joining scion and rootstock.

ROOTSTOCK

When choosing a media in which to plant the rootstocks, make sure it is porous and do not pack the soil too tightly when potting rootstocks ie. Just fill pots around seedling and shake soil into place, packing just enough to support plant. If your media has a high pH, you may have problems with growing rootstocks. The pH limit should be 4.8 to 6.0. If it is too high, can use sulphur to reduce pH. Adding mycorrhizae to soil may stimulate rooting.

Pot rootstocks only a few days (up to a week) prior to grafting and water media thoroughly (Figures 1&2). Reduce greenhouse temperature to around 10 to 15C. Keeping the greenhouse cool and the humidity high will slow down growth, prevent stickiness of buds and acclimatize the (usually) frozen rootstocks to the warmer greenhouse climate. Do not apply nutrients until graft union has taken and the new scion is actively growing and you are sure the graft has taken. There are enough nutrients in the media to support the plant for several weeks. If you have stock already potted in the fall and need to store them for grafting later in February or March, soak the media in the pots, and place the pots in a large, sealed poly bag and keep in the cooler at about -2C. It is a good idea to move these to 1C or 5C for a few days before bringing them to the cool greenhouse.

It is important that roostocks are kept in humid conditions up to and immediately following grafting. To keep humidity up once the potted rootstocks are in the greenhouse, a plastic tent can be built over the greenhouse benches. This keeps the media from drying out in the pots and less watering has to be done prior to the grafting procedure.

GRAFTING

Grafting should be done as soon as possible after the potted balsam fir are brought into the greenhouse. If they are left too long and begin to break bud, the plants will become very sticky and hard to work with. The grafting method used is called the side-veneer graft. It is relatively easy and has proven successful for conifers when the diameter of the scions matches that of the rootstock. The following procedures work well for balsam fir.

- Make sure the grafting knife is very sharp this requires sharpening every 20 plants or so. Clean the knife after each graft with ethanol and let it evaporate before making the cut.

- Trim branches on the rootstock right up to the top leaving only the top whorl of branches. More energy goes into the graft union than to growing side branches.

- Trim needles and buds from the base of the scion for about two-thirds of it's length. Make single, long cuts and do not whittle (Figure 4). The cut should not be too deep (one-third way through the scion or less).

- Make a matching cut on the rootstock so that the cambium layer on one side lines up for sure (two sides is a rare bonus) (Figure 3). Try to graft on second year wood. If too thin for scion, go to third year wood. At the base of the cut on the rootstock leave a short flap which the scion fits into. Freshly cut surfaces should be kept clean and not touched with fingers.

- Wrap the scion to the rootstock using budding strips, being sure not to make too tight and yet tight enough to hold the cambium layers together (Figure 5). Using Para-Film (5 cm width cut in half) as a sealing/wrapping material works very well (Figure 6). When wrapping, be sure to stretch the Para-Film as you wrap the scion so it seals well and sticks to itself. Be sure to cover all cuts with the Para-Film. If using grafting wax, be sure to keep a thermometer in the wax and keep below 60C. If too hot, tissue will be scalded and may affect the graft union and future growth.

- Put completed grafts in a poly tent and re-water the media to be sure it is wet (Figure 8). You should not have to water these again until you move the greenhouse temperatures back up to a normal (22 to 25C) temperature. Do this after about a week or 10 days to allow the callus to form. It is a good idea to lightly rinse the grafts with water once a day. Do not wet the media but just dampen the grafts themselves. This keeps them cool and keeps the humidity up. After grafts have calloused, remove plastic tent and put greenhouse at normal temperatures. Treat plants like other greenhouse material including temperature, light, water nutrients and humidity

Mature Balsam Fir

Selecting Superior Balsam Fir

Balsam fir scions

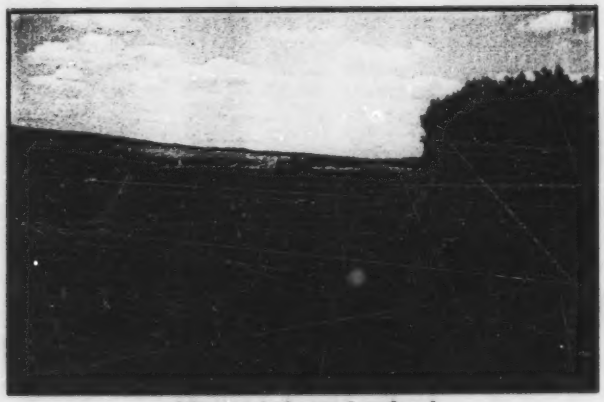
Balsam Fir with superior Colour

Collection of balsam fir scions

Planting Melfort seed orchard

Planting balsam fir graft

Meeting Lake seed orchard



Meeting Lake seed orchard